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History of Materials Science and Evolution of Manufacturing

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Abstract
Objectives of this paper is to examine history of materials science and evolution of manufacturing. The paper examined material science from Stone Age to modern time with their significance role in the development of manufacturing sector in each respective age and the establishment of material science as the field of study led to the development and civilization of mankind, the availability of good quality of materials led to the improve transportation system, tools and equipment for industries, communication, electricity, food, shelter and clothing. Evolution of material science led to the evolution of manufacturing, the selection of material decided of manufacturing process, the selection of technology processes is connected with the materials performance. The study of properties of materials made it easier to select proper manufacturing technology. Based on all the above, it was recommended that Department of Material Science should be well equipped with modern tools and equipment for effective utilization, teachers/researchers should be trained and re-trained in school/colleges across the country.

Keywords: History of Material Science and Evolution of Manufacturing

Introduction

Material consists of matter. It is something on which things can be made from. It exist in the human immediate environment. Chapman (2014) defined materials as substance which occurred naturally from the earth. Materials such as wood, stone, bone, clay, shells, animal skin, fibers, metals and others, the prosperity of any nation highly depends on their ability to turns these materials into a useable article.

The history of materials science is the study of how different materials were used and developed on earth and how those materials affected people's life on the earth. The uses of material to produce object on earth first began with the changing of shapes of materials like wood, bone, stone for useful items by humans. The use of materials on earth begins first in the Stone Age where humans used bone, shells and clay to form weapons, tools, jewelry etc. These tools are called Oldowan and were make from chipped or rocks and used it for scavenging (Wikipedia, 2021). From the Stone Age, we move to Mesolithic Age, by this time tools became more complex and symmetrical in shape with sharp edges. The Mesolithic age led to the Neolithic age where farming (agriculture) started to developing a new form of tools. The use of fire (heat) to change materials from one form to another form started with ceramic around

300,000 Before Common Era and the use of polished stone axes marks a significant advancement in the use of materials because a variety of rocks served as tools and this refers to as Stone Age.

The Bronze Age started with the smelting and casting of metal to form an object in about 5,500 Before Common Era. The early smiths began to re-shape the native metals of copper and gold without the use of fire. The use of fire to heat copper and shaped it with hammer started around 5,000 Before Common Era. The melting and casting of copper and gold begins around 4,000 Before Common Era. The process of producing copper from it ore (Metallurgy) started around 3,500 Before Common Era and the first alloy bronze used by man come around 3,000 Before Common Era. Before the end of the Stone Age, people started using copper, gold, and silver as materials because of the nature of these materials, the normally used it for ornamental/decoration and their usage did not replace other materials used for tools making. The Bronze Age marked the beginning of civilization because it was by this time that the properties of metal such as elasticity and plasticity were known by man and these properties allowed man to hammered copper shapes into the needed pattern. Copper have many advantages but it too soft to find large scale usability. (Lezek, 2006).

Bronze Age led human into Iron Age, in about 1,200 Before Common Era where the use of iron became prominence. By the 3rd century Before Common Era people in ancient India developed what they called Wootz Steel the first crucible made from steel. In the 2nd century Common Era steel making became prominent in Han Dynasty, China. The 4th century Common Era witnessed the production of the Iron pillar of Delhi, the oldest corrosion-resistant steel that development of iron smelting technology. This brought about the decline in bronze usage. By the 10th century Before Common Era glass production began in ancient East.

Middle Age: In the 8th century Common Era, porcelain was invented in China by Tan Dynasty. This resulted in a methodological development of widely used of kilns that could increase the quality and the quantity of porcelain produced. During this early middle age, the technique of creating windows steered more toward glass blowing non-tinted balls that latter flattened but in the late middle ages the methodology returned to antiquity with a few minor adjustments. In the 9th century Common Era, stone paste ceramics was invented in Iraq, and lusterware appeared in Mesopotamia by the 11th century Common Era, Damascus steel was developed in the middle East, in the same vein, Johnnes Gutenberg developed metal alloy in the 15th century Common Era followed by Angel Barovier who invented Cristallo (sodo based class). During the middle Age era, the decrease in mining material and technology began, decrease in precious metal for coinage mint knights had to be paid in land and development of feudal system. Agricultural revolution in Europe, resulted in increased iron production for heavy ploughs and horse shoes. The role of Charlemagne in reestablishing commerce and centralized government ‘Roles of Catholic Church: lead for stained class, bronze for belt making which could also be melted in camon (Ameler, 2017).

Materials Science in Early Modern Period

This period began in 1540 where the first systematic textbook on metallurgy was published by Vannocio Bininguccio. In 17th century Colileo introduced two new ideas in the science of materials these are, the strength of materials and kinetics including the first quantitative statement in the science of materials (Wikipedia, 2021). Before the early 1800s aluminum had not been produced as an isolated metal. It was not until 1825 that Hans Christian discovered how to create elemental aluminum via the reduction of aluminum chloride. Since aluminum is light in weight with good mechanical properties, it was sought to replace heavier less functional metals like silver and gold. Around the 1888 Carl Josef Bayer who work with St. Petersburg. Russia developed a method used for alumina for textile industry and this involved dissolving the aluminum oxide out of the bauxite mineral to produce gibbsite which can be backed into raw alumina.

Material Science in the Modern Time

The term "Silicon Age" is used to refer to the modern period of history of materials science during the late 20th century to early 21st centuries. In the early 20th century, mot engineering school had a Department of Metallurgy and sometime ceramics as well. With much consideration on austenite – martensite – cementite found in iron – carbon (the phase that underline steel production the fundamental understanding of other materials was not sufficiently advanced for them to be considered as academic subjects). After World War II the systematic study of polymers advanced particularly rapidly. Rather than creating a new polymer science department in engineering schools, administrators and scientist began to considered materials science as a new interdisciplinary field. North Western University Instituted the first material science department in 1955. The field of crystallography where x-rays are shown through crystals of a solid material was found by William Henry Brag and His son William Lawrence Bragg at the institute of physic during and after World War II. Materials science became a major discipline during the Silicon Age and Information Age which began with invention of the Metal Oxide Silicon Field Effect Transfer (MOSFET) by Mohammed M. Allela at Bell Labs in 1959. (Wikipedia, 2021).

This led to the development of modern computers and mobile phones with the need to make them smaller, faster, and more powerful. Materials science led to the development of small and lighter materials capable for dealing with more complex calculations. This in turns enabled computers to be used to solve complex crystallographic calculation and automate crystallography experiment, allowing researchers to design more accurate and powerful techniques. Computers are crystallography led to the development of laser technology, from 1960 upwards led to the development of light-emitting diodes used in Direct Video Drive (DVD) players and smart phones, fibrotic communication used in global intercommunications and confocal microscopy, a key tool in material science.

Materials Science as a Field of Study

Most areas of study have their founding fathers like Isaac Newton in the field of Physics and Lavoiseer in the field of Chemistry. But materials science had no one as a founding father. In the 1940s war time, collaborations of multiple fields of study to produce technological advancement became a structure to the future field of study that has become known as materials science and engineering during cold war in the 1950s. During this time, the US President of Science Advisory Committee (PSAC) when he realized that materials were the crucial factor for advance in space and military technology. The Department of defence signed a contract with five University including Harvard, Stanford, Chicago and others and provides them with over $13 million for material research. Then in 1960s many institutions changed the Department of Metallurgy to the Department of Metallurgy and Materials Science (Wikipedia 2021).

Importance of Material Science to Man

Material science has shaped the development and civilization of mankind. Availability of good quality materials led to the development of sophisticated weapons for war, improve transportation system, tools and equipment's for industries, communication, electronic, shelter, food, clothing. The study of materials science continues to create a positive impact on human society, today the study of material science has led to the establishment of industries, and industries bring about manufacturing of goods which man needed for survival.

Material Science and Evolution of Manufacturing

Manufacturing come from the Latin words – *manus* and *facere* which means to make by hand. However, the word has come to mean – the making of a product to be sold for profit.

Manufacturing evolve from domestic system of providing food, shelter, clothing, weapons tools (including farm tools) and ornament for individual or family use. This system went on for thousands of years until when people become more skilled enough to produce more goods that would be used in the household. Since there was no money, people started to barter excess product for other goods of need; thereby making profit from these produces.

Early manufacturing system can be described as home handcraft system in which craftsmen were independent, worked at home as hard as possible and own the tools. As people grew more skillful in making and using sample tools, these people explore most of the globe. (Hummel,2005).

Manufacturing is a process that feature the grounds for satisfying the needs of contemporary societies. Manufacturing is the process of transforming a raw material into a product. Manufacturing is concerned with making product from the raw materials in various processes using various machines and in operation, organized according to the well-prepared plan. Manufacturing process consist of proper use of resource such as materials, capital, energy and people. It is a complex activity merging people working in various professions and carrying

out miscellaneous job using diverse machine, computer and tools automated to a various extent, including computers and robots. Manufacturing in a global scale involves so many technologies and pertains to a wide range of product. Such as consumer goods including those made from wood, textiles, polymer materials, food, machines and tools, medicine and electronic. The aim of manufacturing is to satisfy the needs of the people (Leszek 2005).

According to Khurmi, Gupta (2008), Manufacturing plays important role in engineering because it changes the form of materials into the final product. The development of modern manufacturing is dependent on research materials and the product requires many manufacturing processes for these materials, the various processes depending on materials. If it is metal used, the manufacturing processes are classified into five groups namely;

1. Primary shaping processes
2. Machinery processes
3. Surface finishing processes
4. Joining (welding) processes
5. Layout.

The selection of product manufacturing process related to the selection of materials; it is a very important stage of the engineering design process. The selection of materials decided the selection of the manufacturing processes that may be used for the production. The selection of technology processes is connected with the materials performance and limited by hardness, brittleness or plasticity and melting temperature. Some materials are too brittle to be plastic formed. The study of the properties of materials made it easier to select the suitable manufacturing technology. Therefore, there is close relationship between material science and manufacturing. (Amder, 2017)

Evolution of Manufacturing

Evolution of manufacturing is a term given to the changes that takes place in a global manufacturing system, a revolution of the world economic forum called the industry's greatest change in more than 100 years. The industries have undergone change in few decades. It has been in relative decline since 1970s which accounted for 27% of the UK's economic value by 2017 the figure was 10 percent but the output is higher. United Kingdom is now producing more now than what they were produced 30 years ago – 6 percent more but light production costs, cheaper imports and rapid growing economics. In the east have changed the bottom line the key to success is to make industry more efficient and attractive to use the latest advances in technology to bring the innovation that witnessed Britain soar during the first industrial revolution in two centuries ago.

By embracing technology, the manufacturing industries have the potential to completely transform itself from efficiency on the factory floor, where technologies like AR and 3D printing could become commonplace, to distribution and delivery of the final product. Britain is the birthplace of original revolution, in the early 19th century; it was the world's

leading colonial power. They had coal, iron ore deposit to help literally fuel the increasing industries. Britain could tap raw materials from its colonies especially Indian's Cotton and export goods with ease. The demand for goods led to innovation and innovation was the catalyst for some of most important manufacturing technological advancement of the past 700 years. Evolution of manufacturing lead to the expansion of trade: As the demand for goods grew, Britain economy putting pressure on existing infrastructure, iron was used to revolutionize transportation industry including bridges and railways with the relative ease and speed. Together with the transportation of goods, trains and roads people were freely made taking innovation ideas with them spreading best practices. The globalization was born following Britain ground work for industrial transformation, inventions, machines and work ethic was adopted widely. In return, Britain imported the advancement in electricity form US.

The Evolution of Manufacturing Techniques

This is a guide to how manufacturing techniques evolved over the time. Manufacturing techniques evolved over hundred years and the advent of mechanization, mass production, technological advance and emphasis on cost reduction has been the techniques used to produce goods and have changed drastically. Where the first manufacturing process begans: before industrialization, skilled artisans worked on their own to produce commodities, they brought assistants who were trained through apprenticeships and their work was protected through a guild system. The aim was to guard the secrets behind their craftsmanship. As time goes on artisans realized that they could make money by sub-contracting their work to others and a system known as "putting-out" developed in a pre-industrial era, products being produced in rural areas to supplement agricultural workers income. Because job was sent to sub-contractors who worked in larger off-site facilities, more goods could be produced.

Importance of Industrial Revolution to Manufacturing Sector

Manufacturing processes changed rapidly in the 18th century with the onset of the industrial revolution. Items were no longer hand-made, the use of machine manufacturing brought significant changes for industries like glass making industry, mining, textile and agricultural industries, power (electricity) and transportation and this led to the development of many manufacturing system, some of it according to Behzad (2016) includes:

American Manufacturing System

The American manufacturing system was developed in the 19th century, as factories grew bigger and more money was spent on producing goods so the processes became more sophisticated. Mechanization of production and the use of interchangeable part meant manufacturing good became easier, less time-consuming and the entire process could be achieved with more cost effectiveness. Machine tools were used to make production quicker and easier. Another advantage was the required semi-skilled workforce to operate the

machines. These machines were capable of producing standardized, interchangeable part that could be assembled quickly and with little fitting required.

Mass Production

The next logical step to making standardized products was to develop a system that allowed companies to make that product on a grand scale and this led to the development of mass production concept. This way of working really took off in the late 19th century and involved making multiple copies of a product by using assembly line techniques. The end result was very quick turnaround time and cheap production of identical goods.

Just-in-Time Manufacturing

In the 1960s and 1970s, Japan developed a system called Just-in-time production, this is also refers to as the Toyota Production System (TPS) the aim of the TPS was to cut out waste by developing a business model that did not hold stock but simply ordered deliveries of raw materials and components as when they were needed. As a result, companies utilizing this system to make significant cost savings in terms of warehouse space. The system proved popular and was adopted by Western industry in 1980s and is still in used today in many manufacturing firms.

Lean Manufacturing

Lean manufacturing was a method first employed by businesses in the west in the 1990s and the focused was on added value to the manufacturing process and cutting back on anything deemed superfluous this means eliminating waste in the manufacturing process. The knowledge of lean manufacturing came from Toyota production system which suggested that manufacturers should cut out the seven elements namely: waste; transportation, inventory, motion, waiting, over-processing, over production defects. The process was designed to make manufacturing more efficient, this system benefit both the end user and the manufacturers.

Mass Customization

This aims at giving the manufacturers a strategic advantage over the competition and the best value and quality product to the customer. As technology is moving fast and customers expectation are in increase as a result, mass production is no longer satisfying a sophisticated way to manufacturing goods. Instead, customers want custom output on a large scale; this is facilitated by computer-operated manufacturing system that is flexible enough to produce individually customized goods at low cost.

Conclusion

Human interaction with and manipulation of materials is one of the longest stories of mankind. It is richly compelling narrative that can serve as an entry point to introduce engineering and other technological studies. Materials science has shaped the development of

mankind civilization, the history of material is regarded as much important aspect of civilization throughout the entire periods of time having defined as materials used from Stone Age to Modern materials science. The studies of material science led to the development of manufacturing process that help in turning materials in a valuable product as needed by man and this act as a catalyst for development and modern civilization of man on earth. Manufacturing continue to evolve from concept of development to method and tools/equipment needed for the production of commodities for man's use. Manufacturing refers to an industrial production process in which raw materials are turned into finished products. Nowadays, manufacturing is considered to be integrated concept at all levels, from machine to production system to the entire operation. The development in manufacturing techniques and process, the scope of and the elements of manufacturing are very broad and not easily defined. This paper examines materials from Stone Age to Modern time and the advantages of material toward the development of manufacturing processes and techniques.

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